

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Attorney Docket No.: 322-00091 (FF39041/06)

Applicant(s)	Alexander et al.)	
)	
Serial No:	10/531549)	Examiner:
)	Jill Grey
Confirmation No:	1418)	
)	Art Unit:
Filed:	October 27, 2005)	1794
)	
For:	FIRE RESISTANT POLYMERIC)	
	COMPOSITIONS)	

DECLARATION UNDER 37 CFR § 1.132 OF
PULAHINGE DON DAYANANDA RODRIGO

Commissioner of Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Sir:

I, Pulahinge Don Dayananda Rodrigo; hereby declare:

1. I am the Pulahinge Don Dayananda Rodrigo, named as an inventor in the application.
2. I am qualified as a Materials Scientist having obtained the degree of Doctor of Philosophy (PhD) in Materials Science from the University of Limoges, France, in 1986.
3. My work experience includes over 20 years in the ceramics industry involved in research and development of ceramic materials. Since 2002 I have been employed as a Senior Research Fellow, at Monash University, Clayton, Victoria, Australia, in which capacity I have conducted research in relation to polymeric compositions filled with inorganic materials, which, in a fire, form a ceramic so as

to provide a barrier to the spread of fire and/or preserve communications cables required for evacuation, or fire fighting in the event of a fire.

A copy of my work listing is enclosed as Exhibit 1 hereto.

4. As a result of my qualifications and work experience, I have attained a high level of knowledge in relation to the chemical and physical properties of ceramics in general and, in particular, filled polymer compositions which form a ceramic residue in a fire.
5. I have read the Examination Report of October 7, 2008, in which the Examiner has rejected the claims.
6. The Examiner has questioned the meaning of the words "fluxing oxide". The word "flux" has a number of possible meanings referred to in a technical dictionary, however, in the context of the field of the present patent application, a flux is a liquid phase formed by materials in a high melting substance. The words "flux" and "fluxing oxide" are commonly used in the ceramics and glass industry to refer to materials which interact with a high melting material to form a liquid phase at much lower temperature than would be otherwise required. For example, in the glass industry fluxes such as potash and soda are used to lower the melting point and produce fusion of silica. Fluxes are also used in enamels to reduce the fusion point to below that of the substrate to which they are applied.
7. The Examiner has rejected the claims as not novel or obvious over Romenesko et al. (US 6433049).
8. Romenesko et al. teaches compositions for cable insulation which contain thermoplastic silicone resin in a thermoplastic polyolefin, together with calcium silicate, such as Wollastonite.

Wollastonite is a silicate mineral, but does not contain fluxing oxides or materials which with silicates produce a liquid phase at less than 1000°C.

9. The Romenesko et al. invention is based on the use of a hydrosilation catalyst to produce a more fire resistant material and produce tougher char when compared with mixtures of polyolefins, polyorganosiloxane and calcium silicate, where the polyorganosiloxane is not cured after mixing [Col. 3, line 60 to Col. 4, line 4].
10. Whereas Romenesko et al. obtains tougher char compared to mixtures of polyolefin, polyorganosiloxane and calcium silicate by curing the polyorganosiloxane after mixing. In contrast, the present invention achieves greater char strength through use of a defined proportion of certain fluxing oxides which by forming a liquid phase in a fire were found by myself and co-inventors to adhere the particles of silicate mineral in the ceramic residue which remains after a fire.
11. To examine the effect of the present invention on mixtures of polyolefin, polyorganosiloxane and Wollastonite (calcium silicate) referred to as the base mixture for the Romenesko et al., I chose to examine composition 1-4 of Table 1 of Romenesko et al. without the hydrosilation catalyst ("CATALYST" in composition 1-4 of Romenesko et al.) and curing after mixing. I chose the composition 1-4 of Romenesko et al. because it is the exemplified composition of polyolefin, polyorganosiloxane and calcium silicate which most closely matches the requirement for organic polymer, and silicate mineral (with optional polyorganosiloxane) in the current invention. I prepared the compositions in Table 1:

Table 1	Romenesko et al. Base		Current Invention	
	(g)	(%)	(g)	(%)
Polyolefin (HDPE or LLDPE)	60.0	30.0	60.0	30.0
Silicone with crosslinker	46.8	23.4	46.8	23.4
Wollastonite	93.2	46.6	78.2	39.1
Glass#3			15.0	7.5
Residue		58.5		58.5

The glass #3 composition was as follows:

	Mpt
33.5% SiO ₂	Over 1600°C
18.2% Na ₂ O	~930 °C (d)
10.8% K ₂ O	<765 °C (d)
19.3% TiO ₂	Over 1640 °C
1.8% P ₂ O ₅	~570 °C
8.7% V ₂ O ₅	~690 °C
7.7% Other	Not known

Note: Some of the fluxing oxides decompose instead of melting at atmospheric pressure – (d) is shown in front of melting point to indicate that. Therefore the melting points given here are approximate. However it must be noted that those fluxing oxides react with the silicate mineral present to form a liquid phase (or flux). That is how many fluxing oxides lead to the formation of liquid phase, particularly K₂O and Na₂O.

12. The fluxing oxide content of the composition of Table 1 is thus 39.5% of the glass composition which in the residue represents 5.1% fluxing oxide by weight of the residue remaining after exposure to an elevated temperature experienced under fire conditions.
13. I used glass in the composition of the current invention to reflect the requirement of claim 1 for fluxing oxide in an amount of from 1 to 15% by weight of the residue after firing. In the presence of glass the content of Wollastonite in the "Current Invention" composition of Table 1 was decreased slightly to maintain the same total inorganic residue, so that the compositions can be directly compared.
14. Compositions of the Romenesko et al. base composition and of the current invention shown in Table 1 were each formed into two sets each of identical plaques each plaque being of dimension 70mm x 25mm x 6mm and each were fired in a muffle furnace, one of each of the sets of plaques at 700°C and one of each at 900°C.
15. The results obtained from firing of the composition of Table 1 in the muffle furnace are reported in Tables 2 and 3 below.

Table 2

700°C Testing	Flexural strength by 3-point bending 20mm span
Romenesko et al. Base Composition	0.02
Current Invention	1.06

Table 3

900°C Testing	Flexural strength by 3-point bending 20mm span
Romenesko et al. Base Composition	0.06
Current Invention	1.26

In the 700° and 900° firing tests, the current invention composition proved to be 53 and 21 times stronger in flexural strength than the corresponding base compositions of Romenesko et al.

16. There is nothing in Romenesko et al. to suggest the use of materials which could be described as fluxing oxides let alone those belonging to the specific groups required by claim 1 of the Current Application. Moreover, Romenesko et al. does not teach or suggest that improvements in strength could be obtained other than by use of a hydrosilation catalyst and curing after mixing. The need for curing after mixing also places limitations on the processing of the composition which are not required for compositions of the current invention.

I further declare that all statements made in this declaration of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that wilful false statements may jeopardize the validity of the application or any patent issuing therein.

Date: 26/03/2009


 Pulahinge Don Dayananda Rodrigo

Pulahinge Don Dayananda RODRIGO**9 Murillo Court, Doncaster, VIC 3108, Australia****Telephone: 04 2582 8810 (Mob)/ 03 9848 1486 (Home) / 03 9905 9996 (Work)****E-mail: don.rodrigo@eng.monash.edu.au****WORK HISTORY/ACCOMPLISHMENTS****MONASH UNIVERSITY, AUSTRALIA****Dec. 2002 -Present****Senior Research Fellow, Department of Materials Engineering**

- Conduct independent hands-on research on developing fire-resistant polymer-ceramic composite materials for various passive fire protection applications including insulation for fire-rated electric cables. Play a key role in determining the direction of the research project at all stages. This work has lead to the development of many distinct classes of ceramifying polymeric materials suitable for use in fire-rated electric cables and in other fire-barrier applications. One of these developments has already been commercialized, winning two awards (CRC Association Award for Excellence in Innovation - 2004 and CRC for Polymers Chairman's Award for Excellence in Commercialization - 2004). Other classes of new fire-barrier materials have been developed for use in applications such as fire-door glazing seals and fire-rated elements in building structures.
- Supervise the work of junior researchers associated with the above project.
- Coordinate the work under the above project, done by many researchers at seven different sites (Monash University, UNSW, RMIT, CSIRO, Olex Cables, Ceram Polymerik and DSTO).
- Took a leading role in identifying intellectual property resulting from the above research work, establishing clearly the intellectual property position and finalising six patent applications in consultation with patent attorneys.
- Developed a procedure for evaluating high-temperature electrical properties of ceramifying cable insulations.
- Supervised post-graduate and undergraduate researchers working in areas related to fire-resistant polymeric materials.
- Taught "Structural Ceramics" (Fourth Year Subject in Materials Engineering) and "Ceramic Processing" (Third Year Subject in Materials Engineering).

CERAMIC FUEL CELLS LIMITED, AUSTRALIA**Sept. 2000 - Aug. 2002****Senior Materials Scientist**

- Developed alumina-reinforced yttria-stabilised zirconia (YSZ) materials and tape casting processes for manufacturing electrolyte and interconnect plates for an all-ceramic, planar, solid oxide fuel cell stacks.

- Developed YSZ-NiO-CeO₂ composite materials and manufacturing processes for anode and fuel distribution layers of electrolyte supported solid oxide fuel cells.
- Developed a ceramic gas separator / interconnect plate with built-in current collectors and electrical connectors, capable of being thermally cycled from 850 °C to ambient temperature with no detectable performance or structural degradation.
- Designed and built equipment to measure the gas permeability of thin porous layers deposited on dense substrates.
- Developed and documented functional and manufacturing requirements of all components of an internally manifolded, all-ceramic, solid oxide fuel cell stack of electrolyte-supported, planar, cell design.
- Supervised and provided technical leadership to many taskforces responsible for the design and manufacture of solid oxide fuel cell components from concept generation stage through proof of concept stage to verification & validation stage.
- Headed the taskforces responsible for (1) developing gas separator / interconnect plate, (2) verifying performance of all-ceramic solid oxide fuel cell stacks and (3) characterising anode.
- Carried out day-to-day resource management of the Materials Processing group.

CSIRO MANUF. SCIENCE & TECH., AUSTRALIA
Research Scientist

July 1997 - July 2000

- Conducted an extensive study on the effects of die-casting conditions, section thickness of the casting and application of protective coatings (anodic and powder coatings) on the mechanical properties of die-cast Mg alloy (AZ91D, AM60B, AS21) components. Ensured successful completion of this project, sponsored by the Department of Energy, USA, by co-ordinating R&D activities in 7 locations (three in USA, three in Australia and one in New Zealand) while making over 20,000 die-castings using a cold chamber machine and a seven-cavity die and characterising them.
- Conducted further research on various aspects of Die-Casting Mg Alloys with emphasis on the following:
 - effects of casting conditions on the microstructural features of the products.
 - correlation between the microstructural features and mechanical properties.
 - optimum die casting conditions for common commercial Mg alloys.
 - effects of low temperature ageing on microstructure and mechanical properties of AZ91D and AM60B alloy die-castings.
 - causes of banded defects.
- Supervised a postgraduate research project and participated in the formulation of project proposals to attract external funds.

THE UNIVERSITY OF MELBOURNE, AUSTRALIA
Research Fellow, Dept. of Mechanical and Manufacturing Engineering

Feb. 1995 - June 1997

- Designed and setup a facility having a 15kg/batch capacity for making ceramic particulate reinforced Metal Matrix Composites (MMCs) by semi-liquid/semi-solid processing.

- Developed a process to make aluminium MMCs with particulate reinforcements (mainly hollow flyash), optimised process parameters and transferred the technology to build a pilot plant of 100kg/batch capacity.
- Developed aluminium alloys and MMCs having globular grain structures, suitable for semi-solid forming.
- Contributed to the formulation of project proposals to attract external funds and supervised undergraduate research projects.

THE UNIVERSITY OF MORATUWA, SRI LANKA**Head/Senior Lecturer, Department of Materials Engineering, Aug. 1988 - Dec. 1994****Senior Lecturer, Department of Materials Engineering, June 1986 - Aug. 1988****Assistant Lecturer, Department of Materials Engineering, Nov. 1981 - Dec. 1982**

- Taught many subjects including Properties of Materials, Strength of Materials, Ceramic Science, Ceramic Manufacture, Special Ceramics, Engineering Chemistry, Composites, Mechanical Behaviour of Materials, Microscopy, X-ray Diffraction, Corrosion, Non-Destructive Testing and Electrical Properties of Materials.
- Supervised 19 undergraduate research projects and 4 postgraduate research projects.
- Established a well-equipped materials characterisation laboratory consisting of facilities for XRD, SEM, Thermal Analysis (DTA, TGA, TMA, DSC), Mechanical Testing, IRS and AAS. Funds were raised by undertaking contract research and also from donor agencies.
- Prepared and implemented programs to develop academic and research strengths of the Department. This included liaising with other academic institutions and local industries.
- Nearly doubled the Materials Engineering student intake by introducing programs to increase the employability of graduates.
- Provided leadership, guidance and encouragement to the academic staff and conducted their performance planning and evaluation.
- Advised various government bodies and industries on matters related to the field of Materials Engineering.
- As a member of the University Senate, participated in university-wide policy planning and decision making with regard to both academic and administrative matters.

SRI LANKA STANDARDS INSTITUTION**Mar. 1988 - July 1994****Consultant**

- Chaired the technical committee on Plastics in Engineering Applications.
- Contributed to formulation and revision of national (Sri Lanka) standards in the branches of Welding, Non-Destructive Testing, Metals in Engineering Applications and Plastics in Engineering Applications.

DANKOTUWA PORCELAIN (PVT.) LTD., SRI LANKA **Dec. 1988 - Dec. 1990**
Director (Technical)

- Advised technical staff on matters related to Fine China tableware production by slip casting, plastic forming and extrusion.
- Participated in general policy planning and decision making as a member of the Board of Directors.
- Contributed to improving the quality and output of products and reducing the cost of production to a level that enabled the company to become a major supplier of high quality porcelain tableware to exclusive markets in USA, Japan and Europe.
- Contributed to wiping-off previously accumulated losses in 2 years, and winning the prestigious Presidential Award for export oriented companies in Sri Lanka.

THE OPEN UNIVERSITY OF SRI LANKA **Oct. 1987 - Dec. 1990**
Senior Consultant in Mechanical Engineering and Technology

- Formulated course structures in Mechanical Technology.
- Wrote and edited lessons in Metallurgy, Welding and Mechanical Behaviour of Materials for use in distance education program.

THE UNIVERSITY OF LIMOGES, FRANCE **Dec. 1982 - May 1986**
Graduate Research Assistant

- Developed processes to produce dense mullite and mullite-zirconia ceramics by powder pressing and reaction sintering.
- Supervised undergraduate research projects.

CEYLON STEEL CORPORATION, SRI LANKA **July 1980 - Sept. 1980**
Sri Lanka's largest manufacturer of steel products
Assistant Foundry Engineer (Trainee)

- Developed a mould for testing fluidity of molten brass.
- Contributed to alloy/product development and supervision of the sand casting department.

CEYLON CERAMICS CORPORATION, SRI LANKA, **June 1979 - Aug. 1979**
Sri Lanka's largest manufacturer of ceramic sanitaryware, tableware and mosaic tiles.
Assistant Production Engineer (Trainee)

- Improved the crazing resistance of tableware by re-formulating the glaze and the body and modifying the firing cycle.
- Contributed to glaze development and supervision of the forming department.

EDUCATIONAL QUALIFICATIONS

- **PhD (Docteur de l'Universite) in Materials Science** – Higher National School of Industrial Ceramics (ENSCI)/University of Limoges, France (1983 - 1986).
- **DEA (Equivalent to MSc) in Materials Science** - University of Limoges, France (1983 - 1984).
- **BSc in Materials Eng. (First Class Honours)** - University of Moratuwa, Sri Lanka (1977 - 1981).

TRAINING

- **Working Collaboratively within a Research Project Team Environment** (one-day course) – School of Enterprise, The University of Melbourne, 28 Sept. 2007.
- **Intellectual Property Workshop** – Innovation Law, Philip Mendes & Bradley Thomas, Brisbane, 27 Sept. 2007.
- **Leadership and Innovation Course with Commercialisation Bootcamp** - Centre for R&D Leadership, The University of Melbourne and Australian Institute for Commercialisation, Brisbane - 14 Aug. to 18 Aug. 2006.
- **Multi Factor Solutions for Product & Process Problems** - Design of Experiments, RMIT University, May 2001.
- **Applied Aspects of Neutron Scattering** - Bhabha Atomic Research Centre, Bombay, India - 21 Nov. to 10 Dec. 1993.
- **Materials Characterisation Using Low and Medium Neutron Flux Reactors** - China Institute for Atomic Energy, Beijing, China - 26 Oct. to 13 Nov. 1992.
- **NDT (Ultrasonic Techniques)** - Atomic Energy Authority, Sri Lanka - 24 July to 9 Aug. and from 22 Sept. to 8 Oct. 1992.

AWARDS RECEIVED

Team awards

- BHERT (Business/High Education Round Table Awards for Outstanding Achievement in Collaboration in Research & Development and Education & Training) Award for Best Collaboration Involving a CRC – 2004.
- CRC Association Award for Excellence in Innovation – 2004.
- CRC for Polymers Chairman's Award for Excellence in Commercialisation – 2004.

Individual awards

- CFCL Award for Best Performing Technical Taskforce Leader – 2001.
- Commonwealth Academic Staff Fellowship – 1994.
- French Government Postgraduate Award – 1982.
- Union Carbide Ceylon Ltd. Prize for the best performance at the B. Sc. Eng. Fourth Year Examination in Materials Engineering, University of Moratuwa – 1981.
- Ceylon Ceramics Corporation Scholarship for the best performance at the B. Sc. Eng. Third Year Examination in Materials Engineering, University of Moratuwa – 1980.
- University of Moratuwa Scholarship for the best performance at the B. Sc. Eng. First Year Examination in Materials, Chemical & Mining Engineering, University of Moratuwa – 1978.

SELECTED PUBLICATIONS

1. **P.D.D.Rodrigo** and P.Boch, "**High Purity Mullite Ceramics by Reaction Sintering**", *Int. J. High Technol. Ceram.*, 1 (1985) pp. 3-30.
2. **P.D.D.Rodrigo** and P.Boch, "**Preparation of High Purity Mullite Ceramics**", *Science of Ceramics 13*, Editions de Physique Publ., Paris, 1986, J. Phys. 47, pp. C1-411.
3. **P.D.D.Rodrigo** and P.Boch, "**Effects of Al_2O_3 : SiO_2 Ratio of the Starting Mixture on the Composition, Microstructure and Mechanical Properties of Mullite Produced by Reaction Sintering**", *Transactions of the Materials Research Society of Japan*, Elsevier Science Publishers Ltd., UK, London (1990) pp.180-191.
4. B.P.S.Peiris, P.G.R.Dharmaratne and **P.D.D.Rodrigo**, "**Improvement of the quality of semi-precious gem stones by heat treatments**", *Report to Sri Lanka Gem Corporation*, Colombo, Sri Lanka, June 1992.
5. L.J.P.Jayantha Manel, H.S.Amarasekara and **P.D.D.Rodrigo**, "**Anatomical Structure, Mechanical Properties and Preservation of Bamboo**", *Report to CISIR*, Colombo, Sri Lanka, September 1994.
6. **P.D.D.Rodrigo**, N.Setargew, P.Fitzgerald, G.Withers and K.Xia, "**Solidification Processing of Aluminium Casting Alloy Reinforced with Ceramic Microspheres for Thixoforming**", *Proceedings of 126th TMS Annual Meeting*, Orlando, Florida, USA, February 1997, Light Metals 1997, pp. 953-960.
7. **P.D.D.Rodrigo**, M.Murray, H.Mao, J.Brevick, C.Mobley, V.Chandrasekar, and R.Esdaile, "**Effects of Section Size and Microstructural Features on the Mechanical Properties of Die Cast AZ91D and AM60B Magnesium Alloy Test Bars**", SAE International Congress and Exposition, Detroit, Michigan, USA, March 1999 - Technical Paper No. 1999-01-0927.
8. **P.D.D.Rodrigo**, M. Murray, H. Mao, V. Chandrasekar, Y. Kisioglu, A. Deshpande, J. Brevick, C. Mobley, and R. Esdaile, "**Fatigue Properties of Die Cast Magnesium Alloys**", SAE International Congress and Exposition, Detroit, Michigan, USA, March 2000 – Technical Paper No. 00M-169.
9. **P.D.D.Rodrigo** and V. Ahuja, "**Effect of Casting Parameters on the Formation of 'Pore-Bands' in Magnesium Die-Castings**", *Proceedings of the Second Israeli International Conference on Magnesium Science & Technology*, Dead Sea, Israel, February 2000, pp. 97-104.
10. **P.D.D.Rodrigo** and M. T. Murray, "**The Influence of Coatings on Mechanical Properties of Die-Cast Magnesium Alloys**", *ADCA Bulletin*, 87 (2001) pp. 12-20.
11. Olivier Bellon, Raj Ratnaraj and **Don Rodrigo**, "**10YSZ based electrolyte materials for electrolyte supported SOFCs**", *Proceedings of 5th European Solid Oxide Fuel Cell Forum*, Lucerne, Switzerland, July 2002, pp. 184-190.

12. K.W. Thomson, **P.D.D. Rodrigo**, C. M. Preston and G.J. Griffin, "**Ceramifying Polymers for Advanced Fire Protection Coatings**" European Coatings Journal, 12 (2006), pp. 34-39.

PATENTS (Co-author)

1. International Patent Application No. **PCT/AU02/00939**, "A fuel cell gas separator plate" (International publication number **WO 03/007403**).
2. International Patent Application No. **PCT/AU2003/000968**, "Fire-resistant silicone polymer compositions" (International publication number **WO 2004013255**).
3. International Patent Application No. **PCT/AU2003/001383**, "Fire resistant polymeric compositions" (International publication number **WO 2004035711**).
4. International Patent Application No. **PCT/AU2004/000410**, "Cable and article design for fire performance" (International publication number **WO 2004088676**).
5. International Patent Application No. **PCT/AU2005/000465**, "Ceramifying composition for fire protection" (International publication number **WO 2005095545**).
6. Australian provisional patent application, "Polymer foam and foam articles for fire protection" (**No. 2007902417**).
7. Australian provisional patent application, "Polymer foam containing heat expandable material and foam articles for fire protection" (**No. 2007902415**).

Mica

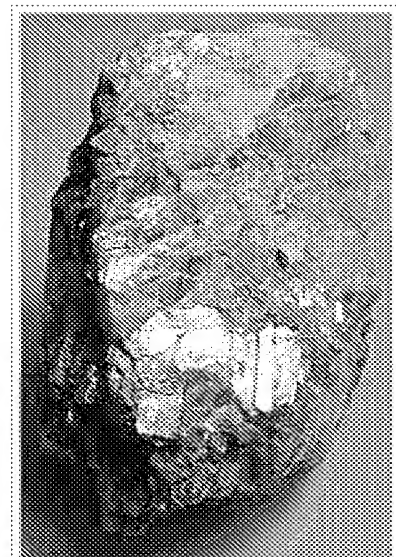
From Wikipedia, the free encyclopedia

The **mica** group of sheet silicate (phyllosilicate) minerals includes several closely related materials having highly perfect basal cleavage. All are monoclinic with a tendency towards pseudo-hexagonal crystals and are similar in chemical composition. The highly perfect cleavage, which is the most prominent characteristic of mica, is explained by the hexagonal sheet-like arrangement of its atoms.

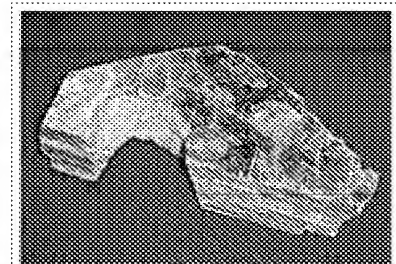
The word "mica" is thought to be derived from the Latin word *micare*, meaning "to glitter", in reference to the brilliant appearance of this mineral (especially when in small scales).

Contents

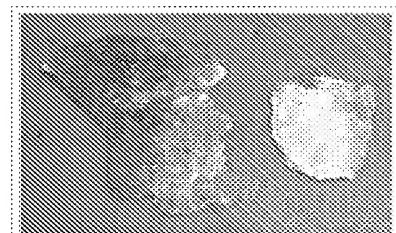
- 1 Mica classification
 - 1.1 Trioctahedral micas
 - 1.2 Interlayer deficient micas
- 2 Occurrence
- 3 Properties and uses
- 4 Isinglass
- 5 Role in primitive life
- 6 Mica in ancient times
- 7 See also
- 8 References
- 9 External links



Rock with mica



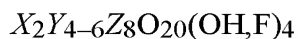
Mica sheet



Mica flakes

Mica classification

Chemically, micas can be given the general formula^[1]



in which *X* is K, Na, or Ca or less commonly Ba, Rb, or Cs;

Y is Al, Mg, or Fe or less commonly Mn, Cr, Ti, Li, etc.;

Z is chiefly Si or Al but also may include Fe³⁺ or Ti.

Structurally the micas can be classed as *disoctahedral* (*Y* = 4) and *trioctahedral* (*Y* = 6). If the *X* ion is K or Na the mica is a *common* mica whereas if the *X* ion is Ca the mica is classed as a *brittle mica*.

Trioctahedral micas

Common micas:

- Phlogopite

- Biotite
- Zinnwaldite
- Lepidolite
- Muscovite

Brittle micas:

- Clintonite

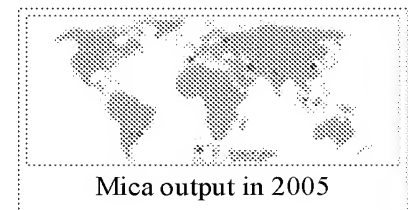
Interlayer deficient micas

Very fine-grained micas with typically more variation in ion and water content are informally termed *clay micas*. They include

- Hydro-muscovite with H_3O^+ along with K in the *X* site;
- Illite with a K deficiency in the *X* site and correspondingly more Si in the *Z* site;
- Phengite with Mg or Fe^{2+} substituting for Al in the *Y* site and a corresponding increase in Si in the *Z* site.

Occurrence

The British Geological Survey reports that as of 2005, India had the largest deposits of mica in world. China was the top producer of mica with almost a third of the global share, closely followed by the USA, South Korea and Canada. Large Deposits of Sheet Mica were mined in New England from the 19th Century to the 1960s. Large mines existed in Connecticut, New Hampshire, and Maine.



Mica is widely distributed and occurs in igneous, metamorphic and sedimentary regimes. Large crystals of mica used for various applications are typically mined from granitic pegmatites.

Until the 19th century, large crystals of mica were quite rare and expensive as a result of the limited supply in Europe. However, its price dramatically dropped when large reserves were found and mined in Africa and South America during the early 1800s. The largest sheet of mica ever mined in the world came from a mine in Denholm, Quebec, Canada.^[2]

Scrap and flake mica is produced all over the world. Flake mica comes from several sources: the metamorphic rock called schist as a by-product of processing feldspar and kaolin resources, from placer deposits, and from pegmatites. Sheet mica is considerably less abundant than flake and scrap mica. Sheet mica is occasionally recovered from mining scrap and flake mica. The most important sources of sheet mica are pegmatite deposits.

Properties and uses

Mica has a high dielectric strength and excellent chemical stability, making it a favoured material for manufacturing capacitors for radio frequency applications. It has also been used as an insulator in high voltage electrical equipment. It is also birefringent and is commonly used to make quarter and half wave plates.

Because mica is resistant to heat it is used instead of glass in windows for stoves and kerosene heaters. It is also used to separate electrical conductors in cables that are designed to have a fire-resistance

rating in order to provide circuit integrity. The idea is to keep the metal conductors from fusing in order to prevent a short-circuit so that the cables remain operational during a fire, which can be important for applications such as emergency lighting.

Illites or *clay micas* have a low cation exchange capacity for 2:1 clays. K⁺ ions between layers of mica prevent swelling by blocking water molecules.

Because mica can be pressed into a thin film, it is often used on Geiger-Müller tubes to detect low penetrating Alpha particles.

Aventurine is a variety of quartz with mica inclusions used as a gemstone.

Pressed mica sheets are often used in place of glass in greenhouses.

Mica is often found in mineral cosmetics.

Some brands of toothpaste include powdered white mica. This acts as a mild abrasive to aid polishing of the tooth surface, and also adds a cosmetically-pleasing glittery shimmer to the paste. The shimmer from mica is also used in makeup, as it gives a translucent "glow" to the skin or helps to mask imperfections.

Mica is used in the production of pearlescent pigments.

Many metallic looking pigments are composed of a substrate of mica coated with another mineral, usually TiO₂. The resultant pigment produces a reflective color depending on the thickness of the coating. These products are used to produce automobile paint, shimmery plastic containers, high quality inks used in advertising and security applications.

Mica sheets are used to provide structure for heating wire (such as in Kanthal or Nichrome) in heating elements and can withstand up to 900 °C (1,650 °F).^{[3][4][5]}

Another use of mica is in the production of ultraflat thin film surfaces (e.g. gold surfaces) using mica as substrate. Although the deposited film surface is still rough due to deposition kinetics, the back side of the film at mica-film interface provides ultraflatness, when the film is removed from the substrate.

Muscovite mica is the most common substrate for sample preparation for the atomic force microscope. Freshly-cleaved mica surfaces have been used as clean imaging substrates in atomic force microscopy, enabling for example the imaging of bismuth films,^[6] plasma glycoproteins,^[7] membrane bilayers,^[8] and DNA molecules.^[9]

Mica slices are used in electronics to provide electric insulation between a heat-generating component and the heat sink used to cool it^[10]. The same word is sometimes used by technicians to designate a synthesised gum (usually blue or gray) which is used for the same purpose, but which does not actually consist of silicate mineral (language abuse).

Isinglass

Thin transparent sheets of mica called "isinglass" were used for peepholes in boilers and lanterns because they were less likely to shatter compared to glass when exposed to extreme temperature gradients. Such peepholes were also used in "isinglass curtains" in horse-drawn carriages and early 20th century cars. A book about a journey in a Model T Ford car describes isinglass curtains as follows:

"Oiled canvas side curtains were put up over the windows for wind, rain, and cold (there were no heaters) and were held in place with rods that fit into the doors and twisting button snaps around the perimeter... 'Isinglass' peepholes in the curtains allowed limited visibility. Isinglass was made of thin sheets of cracked mica."^[11]

Role in primitive life

Helen Hansma, a research scientist affiliated with the University of California, Santa Barbara, has proposed that the unique properties of Mica enabled the formation of life in the oceans of the distant past.^{[12] [13]} In atomic force microscopy, biological samples are placed on mica because it is atomically flat. Even bare DNA molecules may be seen as small ridges. Inspecting mica under the microscope, bits of algae and other organic materials suggested to her the possibility early life molecules could have evolved within mica sheets in a communal fashion eons before the evolution of cell membranes or lipid vesicles. Mica might have provided a secure place with time and space and protection from the open ocean. Further research might provide additional predictions about energy and entropy for life. Mica is old rock—some earliest evidence for life's most primitive cells is in Akilia Island, Greenland, where biotite, a common mica, is also found. Potassium ions, which hold the sheets of mica together, are also required by cells. Primordial soup with amino acids and simple building blocks of life might have seeped between the water-loving mica sheets. The large planar area between sheets might have facilitated the building of long chain molecules. Negative spaces holding the potassium ions on mica are 0.5 nm apart, as are the single stranded DNA molecules (letters of genetic code), as well as amino acids in proteins. Clay also provides spacing that might encourage this process, but the planar area might better encourage the process. Expansion and contraction caused by temperature changes and ocean currents might provide mechanical energy to help rearrange the molecules and trigger the formation of chemical bonds.

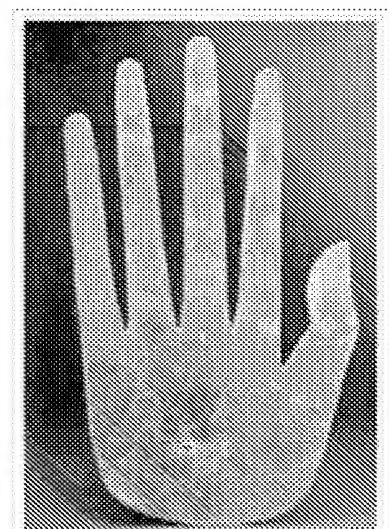
Mica in ancient times

Human use of mica dates back to pre-historic times. Mica was known to ancient Egyptian, Greek and Roman civilizations, Chinese civilization, as well as the Aztec civilization of the New World.

The earliest use of mica has been found in cave paintings created during the Upper Paleolithic period (40,000 BC to 10,000 BC). The first hues were red (iron oxide, hematite, or red ochre) and black (manganese dioxide, pyrolusite), though black from juniper or pine carbons has also been discovered. White from kaolin or mica was used occasionally.

A few kilometers northeast of Mexico City stands the ancient site of Teotihuacan. The most striking visual and striking structure of Teotihuacan is the towering pyramid of the sun. The pyramid contained considerable amounts of locally mined mica in layers up to 30 cm (12 in) thick.^[14]

Throughout the ages, fine powders of mica have been used for various purposes, including decorative purposes. The colored Gulal and Abeer used by Hindus of north India during holi festival contain fine small crystals of mica. The majestic Padmanabhapuram palace, 65 km (40 mi) from Trivandrum in India, has colored mica windows.



Hand carved from mica from the Hopewell tradition

See also

- Mica insulator

References

- ↑ Deer, W. A., R. A. Howie and J. Zussman (1966) *An Introduction to the Rock Forming Minerals*, Longman, ISBN 0-582-44210-9
- ↑ "Denholm" (in French). MRC de La Vallée-de-la-Gatineau. http://www.mrcvg.qc.ca/textes/mun-denholm.shtml. Retrieved on 2008-08-27.
- ↑ "Precision Pressed Products". http://www.precisionv-lmica.com/pp5.html. 071103 precisionv-lmica.com
- ↑ "S & J Trading Inc : Mica Products". http://www.sjmica.com/cat3_prd8.htm. 071103 sjmica.com
- ↑ "Mica Products". http://www.indiamart.com/nsemica/mica-products.html. 071103 indiamart.com
- ↑ Weisenhorn, A. L.; *et al.* (1991). "Atomically resolved images of bismuth films on mica with an atomic force microscope". *Journal of Vacuum Science & Technology, B: Microelectronics and Nanometer Structures* **9** (2): 1333–1335. doi:10.1116/1.585190.
- ↑ Marchant, Roger E.; Lea, A. Scott; Andrade, Joseph D.; Bockenstedt, Paula (1992). *Journal of Colloid and Interface Science* **148** (1): 261–272. doi:10.1016/0021-9797(92)90135-9.
- ↑ Singh, Seema; Keller, David J. (1991). "Atomic force microscopy of supported planar membrane bilayers". *Biophysical Journal* **60** (6): 1401–1410.
- ↑ Thundat, T.; Allison, D. P.; Warmack, R. J.; Brown, G. M.; Jacobson, K. B.; Schrick, J. J.; Ferrell, T. L. *Scanning Microscopy* (1992), 6(4), 911-18
- ↑ See pictures and use on [1] (http://www.bigdaddy-enterprises.com/electronics/e_heatsinks.htm) [2] (http://www.aavidthermalloy.com/products/standard/access/kits.shtml) [3] (http://www.vitacom.ro/Products/OEM/250/MICA-TO220/ISOLATION-TO220.html) [4] (http://www.alliedelec.com/Search/ProductDetail.asp?SKU=935-9422&MPN=NTE422&R=935-9422&sid=480D2A80500DE17F)
- ↑ Joanne Wilke, *Eight Women, Two Model Ts and the American West*, University of Nebraska Press, (2007), ISBN 0803260199
- ↑ Life On Earth May Have Originated As The Organic Filling In A Multilayer Sandwich Of Mica Sheets (http://www.sciencedaily.com/releases/2007/12/071204102500.htm)
- ↑ NPR: Life on Earth May Have Begun In Between Rocks (http://www.npr.org/templates/story/story.php?storyId=17007216)
- ↑ Fagan, Garrett G. (2006). *Archaeological Fantasies: How Pseudoarchaeology Misrepresents the Past and Misleads the Public*. New York: Routledge. pp. 102. ISBN 0415305934.

External links

- Mineral Galleries data (http://www.galleries.com/minerals/silicate/micas.htm)
- Mindat (http://www.mindat.org/min-6728.html)

Retrieved from "http://en.wikipedia.org/wiki/Mica"

Categories: Phyllosilicates | Dielectrics

Hidden categories: Articles containing Latin language text

- This page was last modified on 12 March 2009, at 18:00.
- All text is available under the terms of the GNU Free Documentation License. (See **Copyrights** for details.)

Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a U.S. registered 501(c)(3) tax-deductible nonprofit charity.

Wollastonite

From Wikipedia, the free encyclopedia

Wollastonite is a calcium inosilicate mineral (CaSiO₃) that may contain small amounts of iron, magnesium, and manganese substituting for calcium. It is usually white. It forms when impure limestone or dolostone is subjected to high temperature and pressure sometimes in the presence of silica-bearing fluids as in skarns or contact metamorphic rocks. Associated minerals include garnets, vesuvianite, diopside, tremolite, epidote, plagioclase feldspar, pyroxene and calcite. It is named after the English chemist and mineralogist William Hyde Wollaston (1766–1828).

Some of the properties that make wollastonite so useful are its high brightness and whiteness, low moisture and oil absorption, and low volatile content. Wollastonite is used primarily in ceramics, friction products (brakes and clutches), metalmaking, paint filler, and plastics.

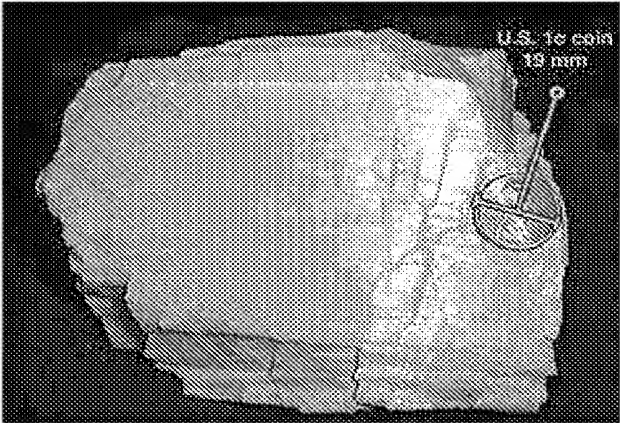
Despite its chemical similarity to the compositional spectrum of the pyroxene group of minerals—where magnesium and iron substitution for calcium ends with diopside and hedenbergite respectively—it is structurally very different, with a third SiO₄ tetrahedron^[4] in the linked chain (as opposed to two in the pyroxenes).

Contents

- 1 Production trends
- 2 Uses
- 3 Composition
- 4 Geologic Occurrence
- 5 Structure
- 6 Physical & Optical Properties
- 7 See also
- 8 References
- 9 External links

Production trends

Wollastonite

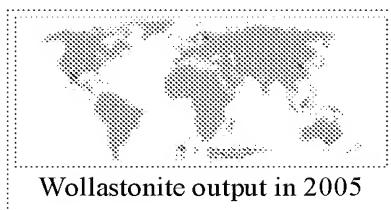


General

Category	Silicate mineral
Chemical formula	Calcium silicate, CaSiO ₃

Identification

Color	white, colorless or gray
Crystal habit	rare tabular crystals - commonly massive in lamellar, radiating, compact and fibrous aggregates.
Crystal system	triclinic bar 1
Cleavage	perfect in two directions at near 90 degrees
Fracture	splintery to uneven
Mohs Scale hardness	4.5 to 5.0
Luster	vitreous or dull to pearly on cleavage surfaces
Refractive index	n α = 1.616 - 1.640 n β = 1.628 - 1.650 n γ = 1.631 - 1.653
Optical Properties	Biaxial (-)
Birefringence	δ = 0.015 max
Streak	White
Specific gravity	2.86 - 3.09
Melting point	1540 °C
Solubility	soluble in HCl, insoluble in water
Diaphaneity	Transparent to translucent
References	[1][2][3]



In 2005, China was the top producer of wollastonite with at least 50% world share followed by India and the USA, reports the British Geological Survey.

In the United States, wollastonite is mined in Willsboro, New York and Gouverneur, New York. Deposits have also been mined commercially in North Western Mexico.

Uses

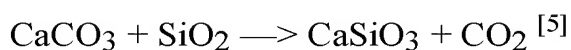
Wollastonite has industrial importance worldwide. It is used in many industries, mostly by tile factories which have incorporated it into the manufacturing of ceramic to improve many aspects, and this is due to its fluxing properties, freedom from volatile constituents, whiteness, and acicular particle shape.^[5] It also can be used in paint, paper, and vinyl tile manufacture. In some industries, it is used in different percentages of impurities such as its use as, a fabricator of mineral wool insulation, or as an ornamental building material.^[6]

Composition

There are two main constituents that form the mineral wollastonite: CaO and SiO₂. In a pure CaSiO₃, each component forms nearly half of the mineral by weight percentage. The CaO has a weight percentage of 48.3 %, and the SiO₂ has a weight percentage of 51.7%. In some cases, small amounts of iron (Fe), and manganese (Mn), and lesser amounts of magnesium (Mg) substitute for Calcium (Ca) in the mineral molecules.^[6] Wollastonite can form a series of solid solutions in the system CaSiO₃-FeSiO₃, or hydrothermal synthesis of phases in the system MnSiO₃-CaSiO₃.^[5]

Geologic Occurrence

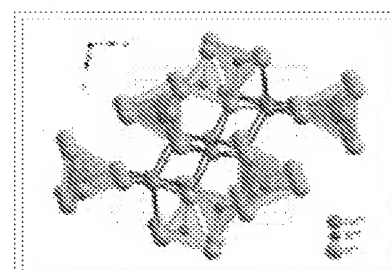
Wollastonite usually occurs as a common constituent of a thermally metamorphosed impure limestone, it also could occur when the silicon is due to metamorphism in contact altered calcareous sediments, or to contamination in the invading igneous rock. In most of these occurrences it is the result of the following reaction between calcite and silica with the loss of carbon dioxide:



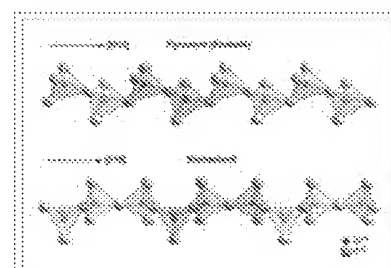
Wollastonite could also develop in a diffusion reaction in skarn, it develops when limestone within a sandstone is metamorphosed by a dyke, which results in the formation of wollastonite in the sandstone as a result of outward migration of Ca.^[5]

Structure

Wollastonite crystallizes triclinically in space group $P\bar{1}$ with the lattice constants $a = 7.94 \text{ \AA}$, $b = 7.32 \text{ \AA}$, $c = 7.07 \text{ \AA}$; $\alpha = 90,03^\circ$, $\beta = 95,37^\circ$, $\gamma = 103,43^\circ$ and six formula units per unit cell.^[7] Wollastonite was once classed structurally among the pyroxene group, because both of these groups have a ratio of Si:O = 1:3. In 1931, Warren and Biscoe showed that the crystal structure of wollastonite differs from minerals of the pyroxene group, and they classified this mineral within a group known as the pyroxenoids.^[5] It has been shown that the pyroxenoid chains are more kinked than those of pyroxene group, and exhibit longer repeat distance. The structure of wollastonite contains infinite chains of $[\text{SiO}_4]$ tetrahedra sharing common vertices, running parallel to the b -axis. The chain motif in wollastonite repeats after three tetrahedra, whereas in pyroxenes only two are needed. The repeat distance in the wollastonite chains is 7.32 \AA and equals the length of the crystallographic b -axis.



Unit cell of triclinic wollastonite-1A



Tetrahedra arrangement within the chains in pyroxenes compared to wollastonite

Physical & Optical Properties

Wollastonite occurs as bladed crystal masses, single crystals can show an acicular particle shape and usually it exhibits a white color, but sometimes cream, grey or very pale green.

The streak of wollastonite is white, and its hardness on mohs' scale ranges between 4.5-5. Its specific gravity ranges between 2.87-3.09. There are more than one cleavage planes for it, there is a perfect cleavage on $\{100\}$, good cleavages on $\{001\}$, and $\{\bar{1}02\}$, and an imperfect cleavage on $\{101\}$. It is common for wollastonite to have a twin axis $[010]$, a composition plane (100), and rarely to have a twin axis $[001]$. The luster is usually vitreous to pearly. The melting point of wollastonite is about $1,540^\circ\text{C}$.

See also

- List of minerals
- List of minerals named after people

References

- ↑ http://www.mindat.org/min-4323.html Mindat
- ↑ http://webmineral.com/data/Wollastonite-1A.shtml Webmineral
- ↑ http://mineral.galleries.com/minerals/silicate/wollasto/wollasto.htm Mineral galleries
- ↑ Deer, Howie & Zussman (1966) *An Introduction to the Rock Forming Minerals*, Longman 528pp + xii, ISBN 0-582-44210-9
- ↑ ^{*a b c d e*} Deer, Howie and Zussman. Rock Forming Minerals; Single Chain Silicates, Vol. 2A, Second Edition, London, The geological society, 1997.
- ↑ ^{*a b*} Andrews, R. W. Wollastonite. London, Her majesty's stationary office, 1970.
- ↑ M. J. Buerger, C. T. Prewitt (1961): *The crystal structures of wollastonite and pectolite*. Proceedings of the National Academy of Sciences, U.S.A., 47, 1884–1888.

External links

- Oxford University MSDS sheet (<http://physchem.ox.ac.uk/MSDS/VO/wollastonite.html>)

Retrieved from "<http://en.wikipedia.org/wiki/Wollastonite>"

Categories: [Calcium minerals](#) | [Silicate minerals](#) | [Metamorphic rocks](#)

- This page was last modified on 26 March 2009, at 17:22.
- All text is available under the terms of the GNU Free Documentation License. (See **Copyrights** for details.)

Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a U.S. registered 501(c)(3) tax-deductible nonprofit charity.